



# — opus 12

CO<sub>2</sub> to value

Heidi Lim, Chief of Staff | [Heidi@Opus-12.com](mailto:Heidi@Opus-12.com)

Prepared for CPUC Workshop



Transforming global CO<sub>2</sub>  
Emissions...



...into a multi-billion dollar opportunity

# Founded at Stanford and Lawrence Berkeley National Lab in 2016

Founding team



**Dr. Kendra Kuhl**  
CTO

PhD in Chemistry, Stanford, Post doc, SLAC  
Research: Transition metal catalyzed CO<sub>2</sub>  
electroreduction, reactor design



**Nicholas Flanders**  
CEO

MS E-IPER, Stanford  
Work Experience: COO/CFO  
Levo, McKinsey CleanTech  
practice



**Dr. Etosha Cave**  
COO

PhD in Mechanical Eng, Stanford  
Research: Modified gold catalysts for  
CO<sub>2</sub> electroreduction, reactor design



**cyclotronroad**



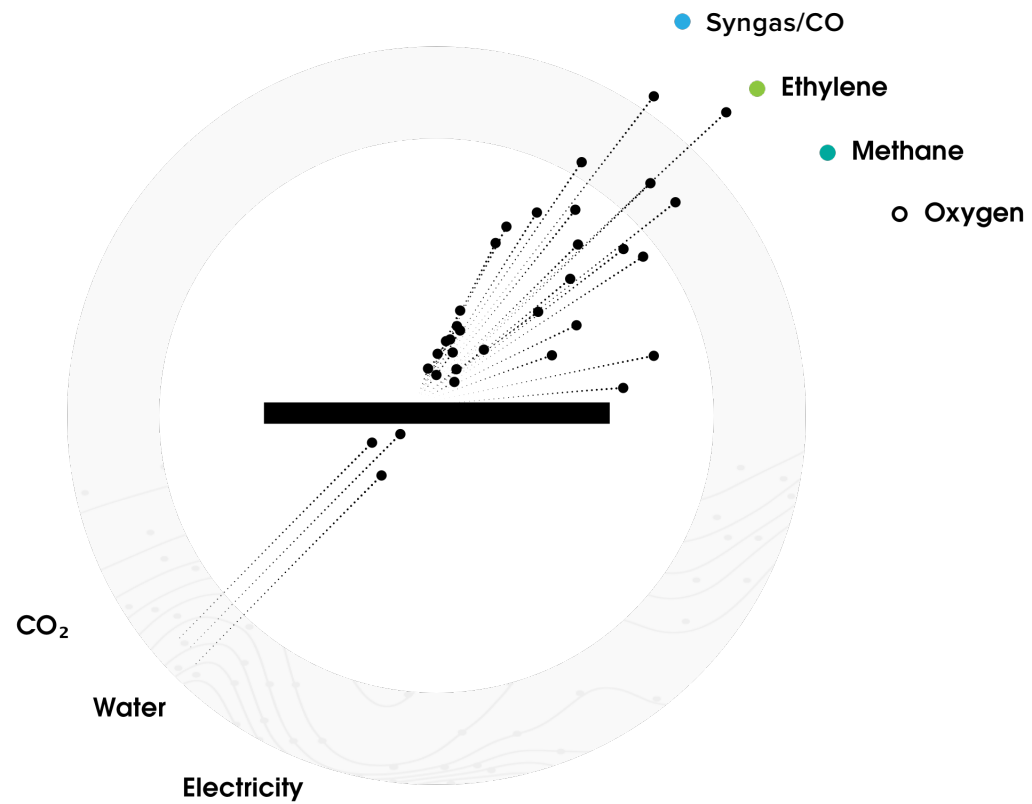
"25 People Shaping the Next 50 Years"



**INNOVATORS  
UNDER 35**

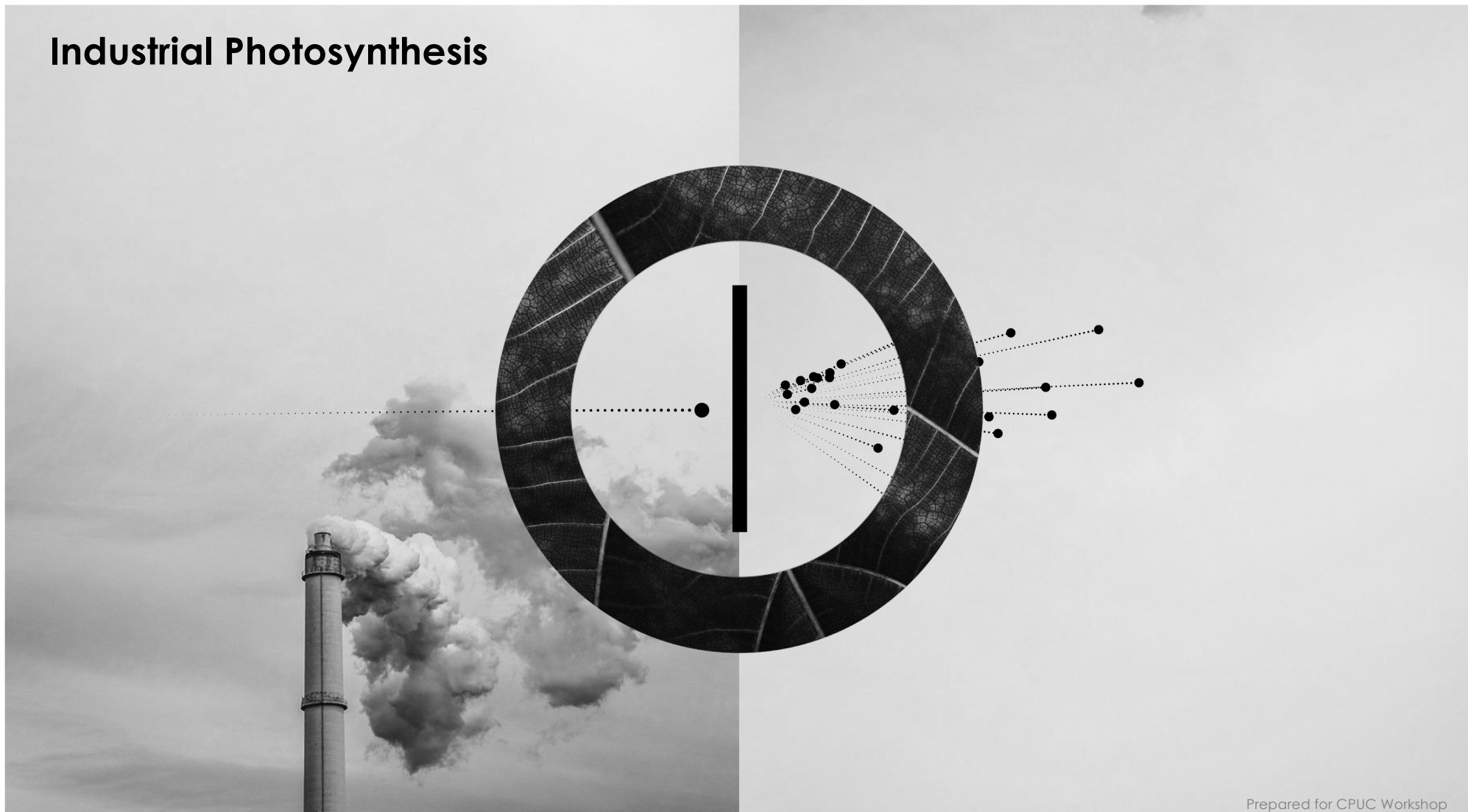


## We transform CO<sub>2</sub> into critical chemical products



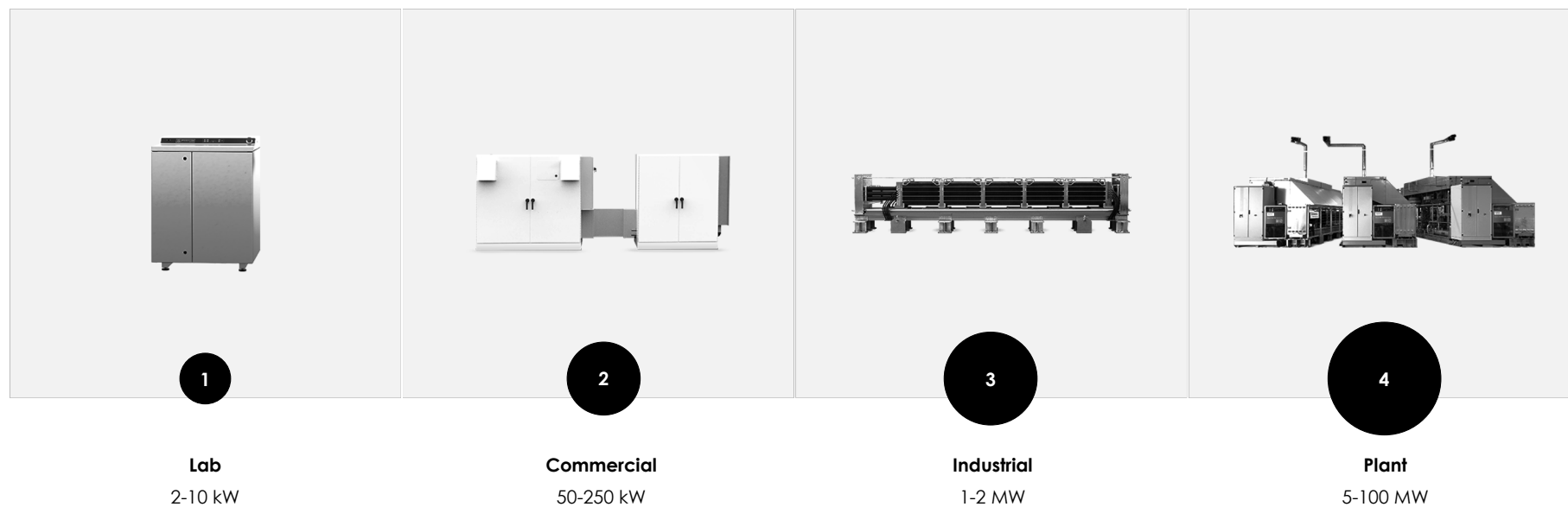


# Industrial Photosynthesis

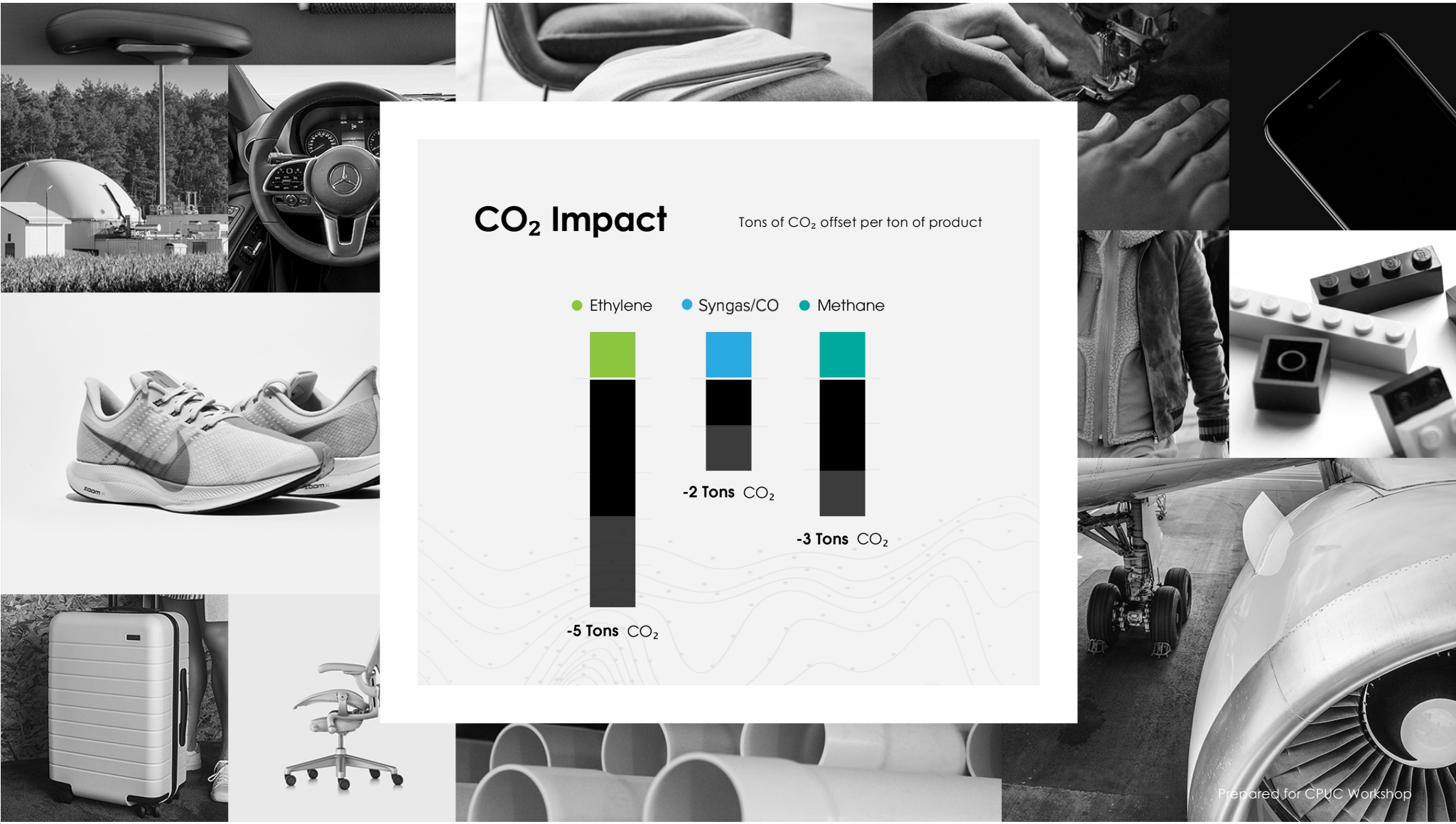


# Known Scale-up Pathway

Integration into existing electrolyzer designs



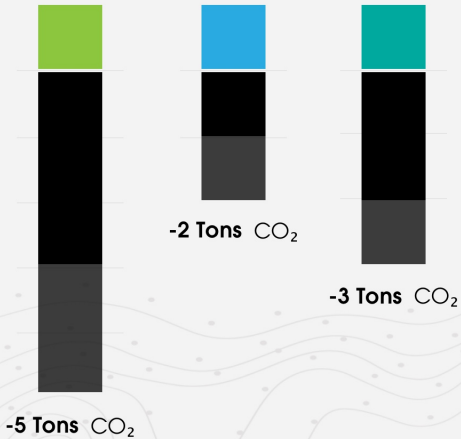
We partner with electrolyzer producers to build CO<sub>2</sub> conversion systems



# CO<sub>2</sub> Impact

Tons of CO<sub>2</sub> offset per ton of product

● Ethylene    ● Syngas/CO    ● Methane



Case Study

## Biogas

Methane ●

**Hog farm in NC (moderate case):**

25-50% increased capacity

\$2M increased annual profit

**Recovered Capacity**



**Recovered**  
\$2M

**Production Today**  
\$6M



**California**

1300 dairies already running methane  
reduction projects

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## CO<sub>2</sub>-to-Methane Collaboration Since 2017



- Successful demonstration of converting biogas (CO<sub>2</sub> + methane) into pure methane in a single electrochemical step.
- Pathway to store excess renewable electricity as storable RNG



April 19, 2018

### SoCalGas and Opus 12 Successfully Demonstrate Technology That Simplifies Conversion of Carbon Dioxide into Storable Renewable Energy

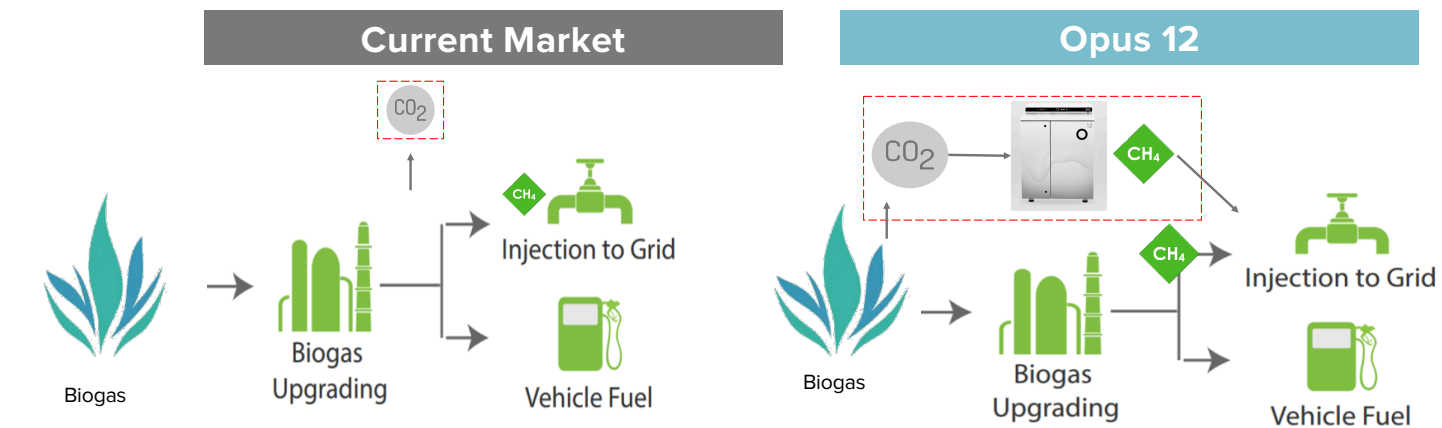
New electrolyzer technology can convert the unwanted carbon dioxide in raw biogas directly to pipeline quality natural gas using renewable electricity

Simplifies process of storing surplus renewable electricity as renewable natural gas

LOS ANGELES, April 19, 2018 /PRNewswire/ -- [Southern California Gas Co.](#) (SoCalGas) and [Opus 12](#) today announced the successful demonstration of a new process to convert the carbon dioxide in raw biogas to methane in a single electrochemical step, a critical improvement in the science of upgrading biogas to pipeline quality natural gas, and a simpler method of converting excess renewable electricity into storable natural gas.

Opus 12, a clean-energy startup incubated in the prestigious [Cyclotron Road](#) program at Lawrence

## Opus 12 CO<sub>2</sub>-to-Methane Process



Biogas  
Utilization:

**~55%**

**~99%**

Pain Points:



Waste ~45% of biogas



Vent CO<sub>2</sub>



Improve methane yield



Reduce CO<sub>2</sub> emissions

## Continuing CO<sub>2</sub>-to-Methane Collaboration

- Current collaboration focused on increasing conversion energy efficiency
- Roadmap to pilots and deployment statewide
- *Advantage:* Removes an entire reaction step vs. alternative methanation (e.g. H<sub>2</sub>+CO<sub>2</sub> with Sabatier or gas fermentation)
- *Impact:* lower capital cost, greater operation simplicity




Case Study

# Jet Fuel

## Carbon-Neutral Jet Fuel



**Regular**  2.5 kg CO<sub>2</sub>/L

**e.jet**  < 0.4 kg CO<sub>2</sub>/L with solar (>85% reduction)

Grams of CO<sub>2</sub> Per Liter

Opus 12's technology converts CO<sub>2</sub> to CO, which is upgraded to jet fuel



# e.jet

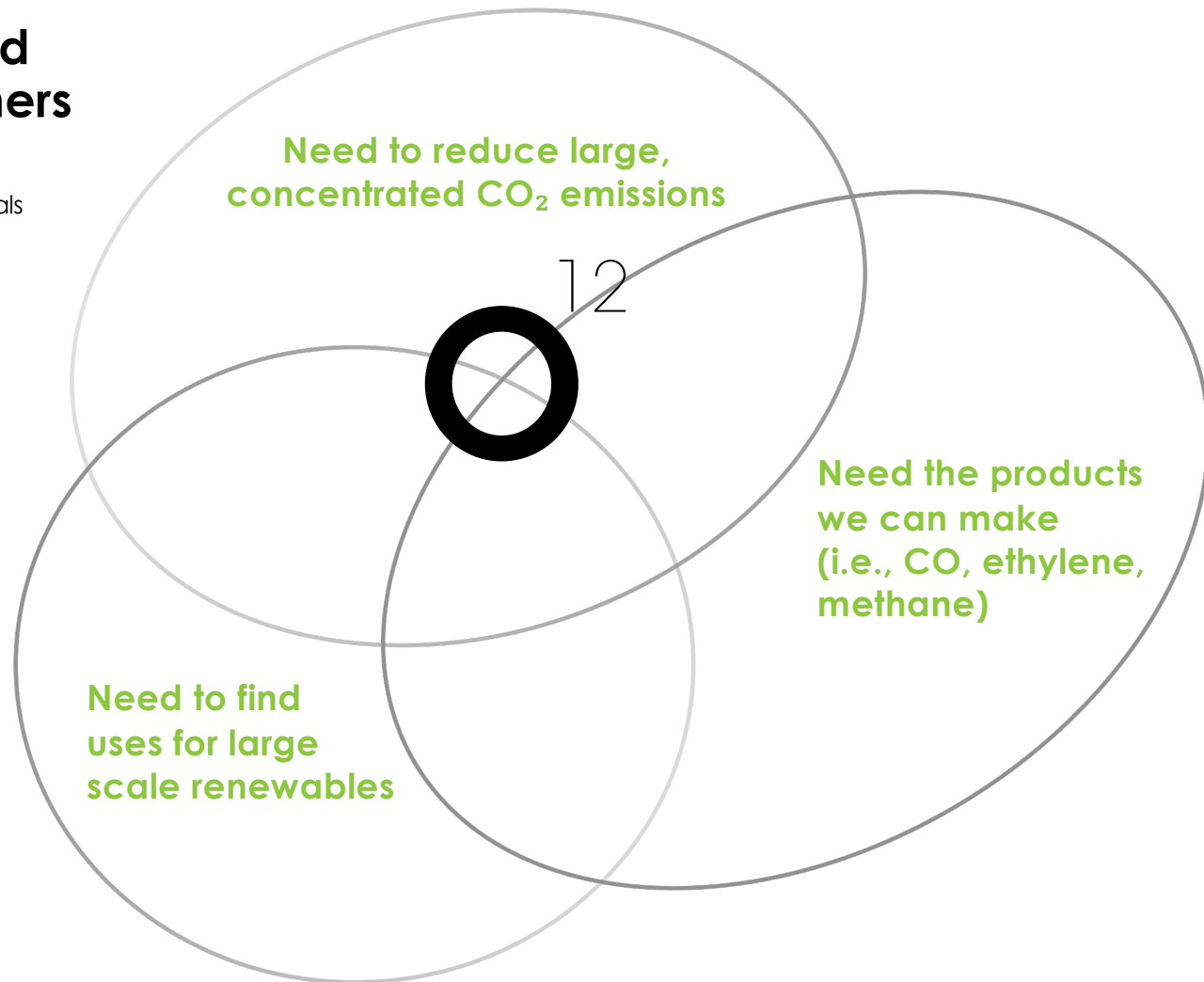
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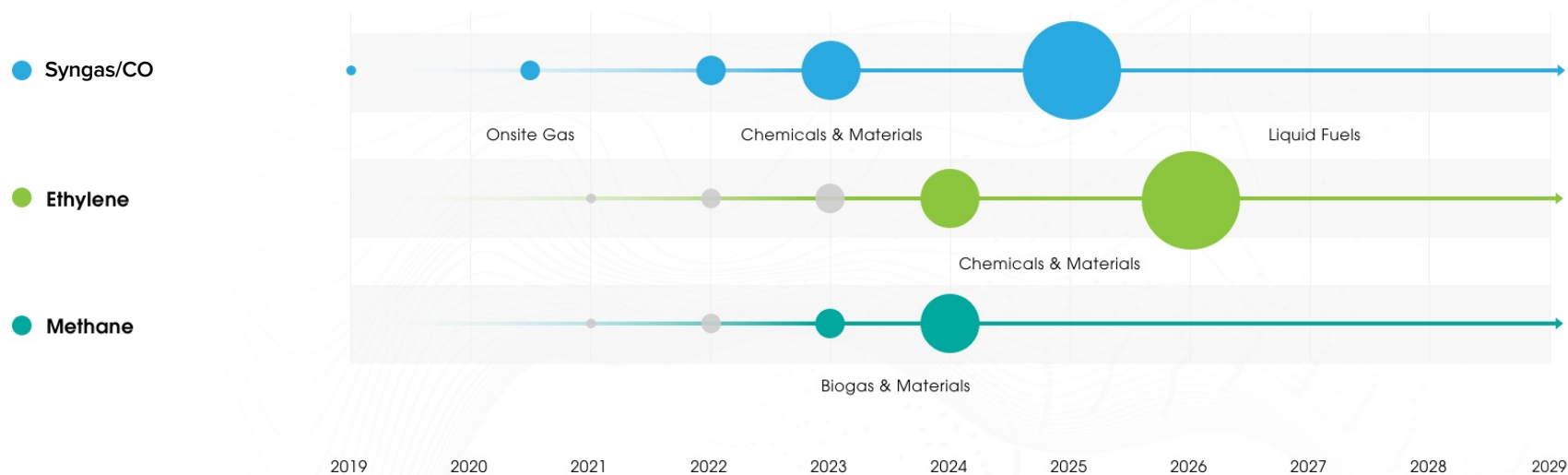
# We have a broad range of customers and partners

At the nexus of energy & materials



# Commercialization plan

We are building a platform technology to produce a range of products from CO<sub>2</sub> at a range of scales



An aerial photograph of a lush, green tropical forest. A river or stream flows through the landscape, with a small settlement or village visible on the right bank. The forest is dense and covers most of the area. The text "37,000 trees in a suitcase" is overlaid in the center of the image.

**37,000 trees in a suitcase**